Exoplanets:
Lessons from the Decadal Review

What went wrong?

What do we do now?

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Why Me?

- I worked on Infrastructure Group of ASTRO2010
  Chaired by Craig Wheeler
  Group was charged with technology development
- I was only member with interest in Exoplanets
- I have labored in technology development for 41 years
  X-ray Astronomy, UV Astronomy, Exoplanets
  Tech Transfer in Medicine and Lithography

ASTRO2010 Organization

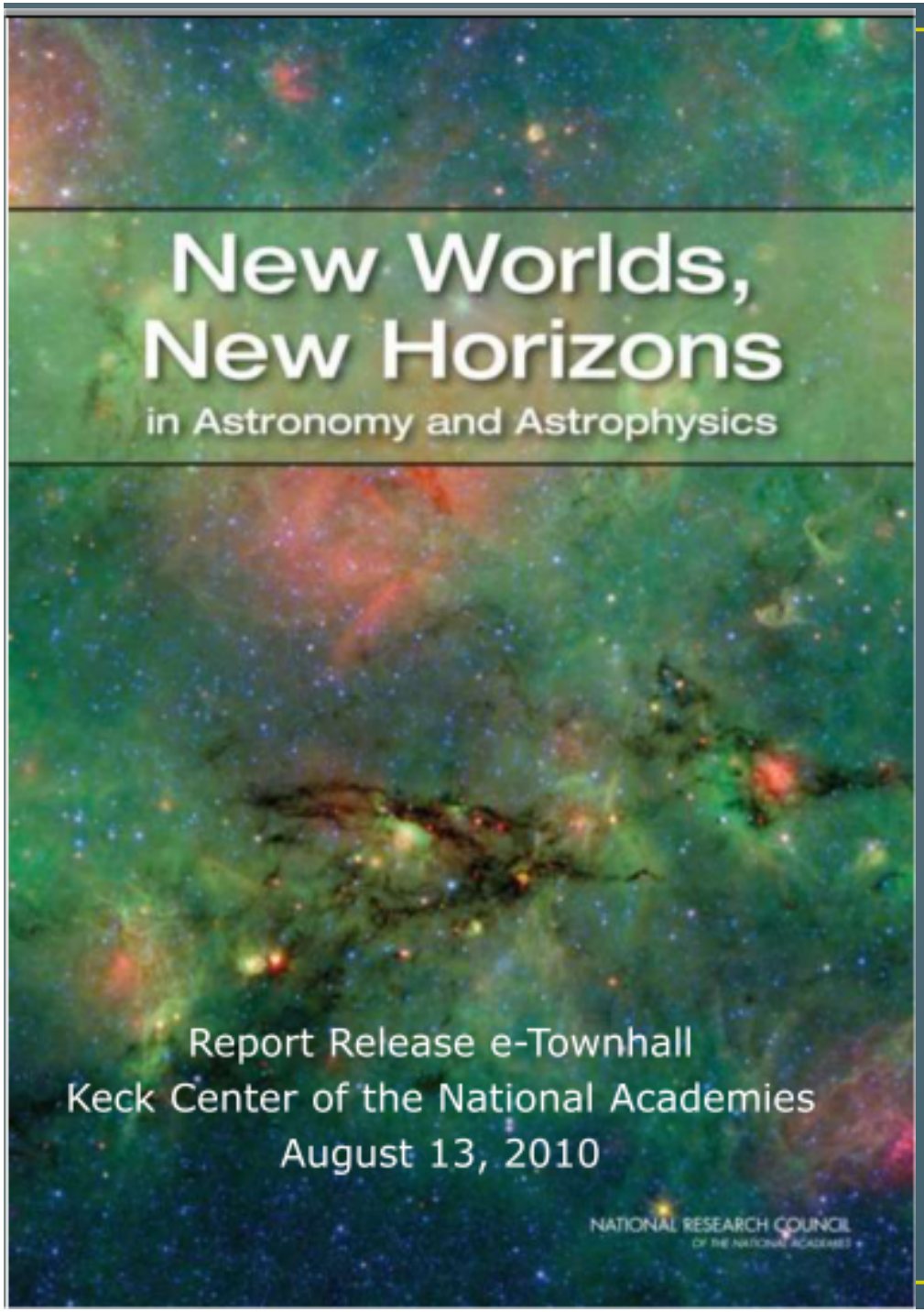
Actual Decadal Committee

Mission Panels

Science Panels

Working Groups

Infrastructure Working Group Discussed Technology Development



ASTRO2010 Report

Look at that title!

What ASTRO2010 Recommended

1. **WFIRST**
   - near IR wide Field
2. **Enhance Explorers x2.5**
   - Explorers remain functional
3. **LISA**
   - Gravity Waves still not seen
   - Won't serve community
4. **IXO**
   - Large x-ray light bucket for spectroscopy

1. **New Worlds Technology Development Program**
   - Note title – Could have called it
     - Navigator Program
     - Terrestrial Planet Finder Program
     - Exoplanet Tech Deve Program

ASTRO2010 Highlighted Exoplanets

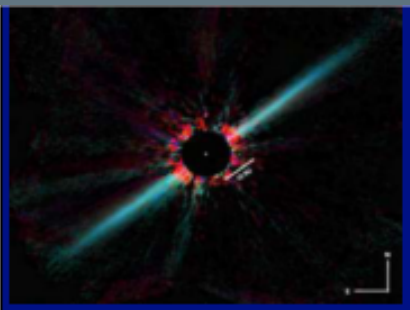
Long sections about life on other planets.

Even though we won't address that this decade.

Must conclude they desperately want spectroscopy of Earths badly.

From Blandford presentation: 8/13/10

#1 Recommendation for NASA in Medium Cost Class



New Worlds Technology Development Program

- To achieve New Worlds objective – studying nearby, habitable exoplanets - need preliminary observations before choosing a flagship mission:
  - Planetary demography over wide range of conditions:
    - Kepler, WFIRST, integrated ground-based program
  - Measurement of zodiacal light:
    - Ground-based telescopes.
    - Sub-orbital and explorer mission opportunities.
- In parallel, need technology development for competing approaches to make informed choice in second half of decade
- **RECOMMEND $100-200M over decade**
- Planned integrated ground-space exoplanet program

Why the Emphasis on a Flagship?

- Simply Finding Planets is No Longer Enough
  - Even Earths in HZ will no longer be cutting edge in 2020
- Goal is Spectroscopy of Earth-like Planets
- That is Going to Take a Large, Expensive Telescope!!!
- Must do spectroscopy of Earths against zodiacal light
  - Sky has 22mag/square arcsec -- Earth at 10pc is m=30
  - So Earth brightness equals sky in 25milliarcsecond spot
  - Diffraction limit of 25mas is achieved with 4m telescope at 0.5μ
  - Observing time rises as 4^{th} power of diameter below that. Confusion issues make it worse
  - Observing time drops as square of diameter above that. Confusion is rapidly reduces.
- ***We Must have a 4m – that's a flagship!***

What Size Flagship Do We Need?

- 4m to do Earth problem right, just based on local zodi

- But exozodi could still kill the flagship.
  - Exozodis could be much brighter. Time goes up as square of B(zodi)
  - Lumpiness factor can further confuse the issue

- So flagship cannot be designed until exozodi known
  - Must know it statistically - >12 G&K stars to 22m/sqas
  - Must know it in Habitable Zone - 0.15 arcseconds

    extrapolation inward not accurate enough

WE MUST KNOW THESE NUMBERS BY 2019

Why No Flagship this Decade?

WE DIDN'T EVEN BREAK THE TOP FOUR

WHY?

We don't know what we need

They don't trust anybody -- JWST problem

They don't trust us to deliver -- history of exoplanet TD poor

They don't trust the new technology to perform the astronomy

THESE ARE THE REASONS THEY INVENTED WFIRST FOR THE TOP SLOT INSTEAD OF TAKING A STUDIED MISSION

Why the Lack of Trust?
Take a look at 2000 Decadal

- Decadal 2000 Recommendations:

1. Finish SIM
2. Do NGST (JWST) $1B
3. Do Constellation-X (IXO) $800M
4. Prepare Terrestrial Planet Finder for 2010
   $200M before 2010, $1.5B after

Outcome of 2000 Recommendations

SIM Never Finished

- Spent something in vicinity of $600M
- Wanted more than a $1Billion more
- Killed because science shelf life had expired

JWST price from $1,000M to ~$8,000M

- Overruns have brought all astrophysics to a halt

Con-X never started

- Spent ~$100M on technology development
- ASTRO2010 added $1.5B risk cost
- Brought projected cost to $5B
- Slipped to fourth place behind LISA

TPF

- Spent ~$200M as directed
- But no missions ready to proceed to flight
- Mulligan! Start again as in 2000

TECHNOLOGY DEVELOPMENT FAILED ACROSS THE BOARD

WE MUST DO IT DIFFERENTLY IN COMING DECADE

BUT,

WHAT ARE THE PROBLEMS?

HOW CAN WE CHANGE?

Edifice of Knowledge

Understanding

Theory

Observing and Data Analysis

Mission Operations

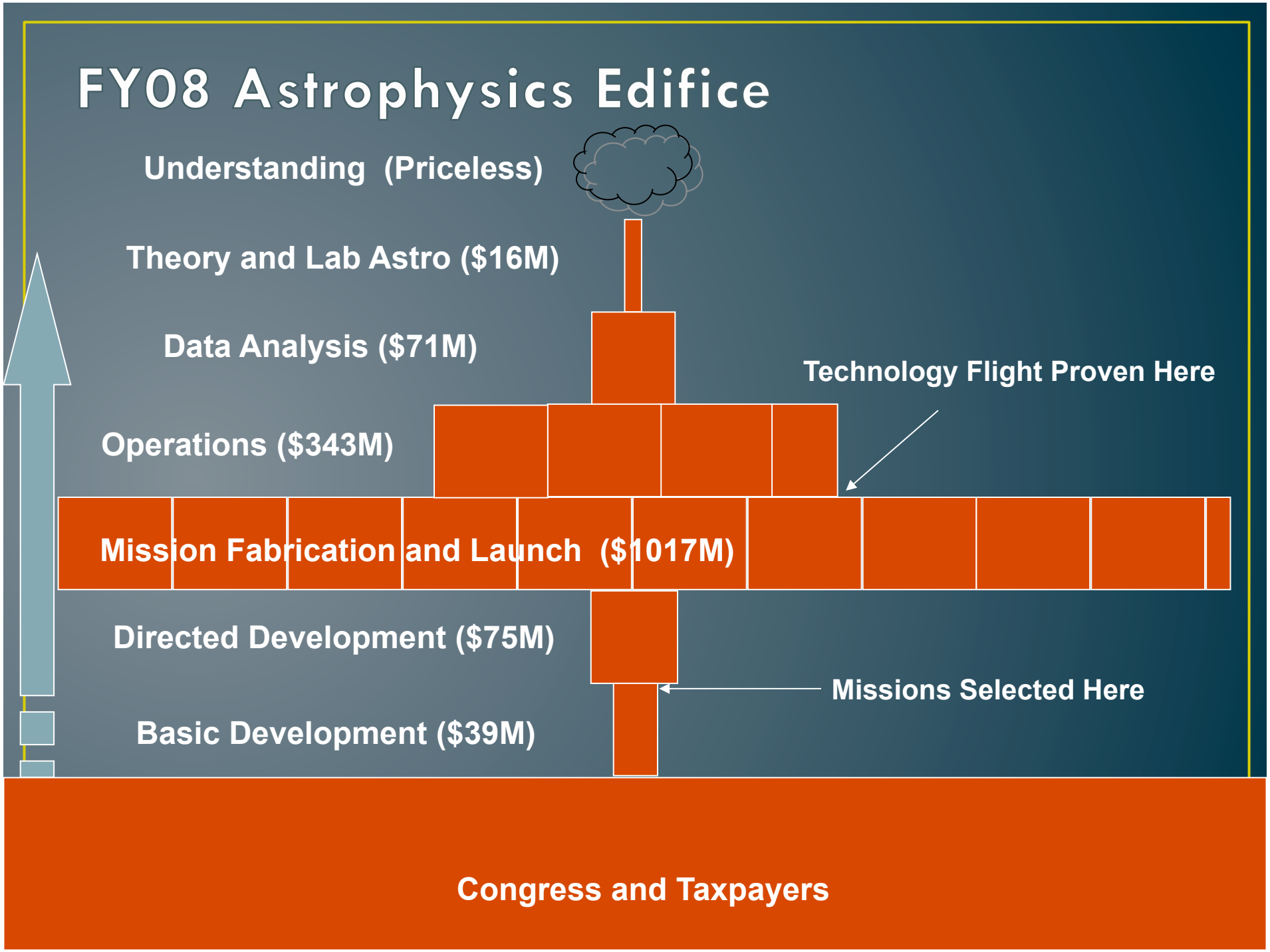
Mission Fabrication and Launch

Directed Development (after architecture chosen)

Basic Development of New Technology

Generate money (Taxes, donations, etc)

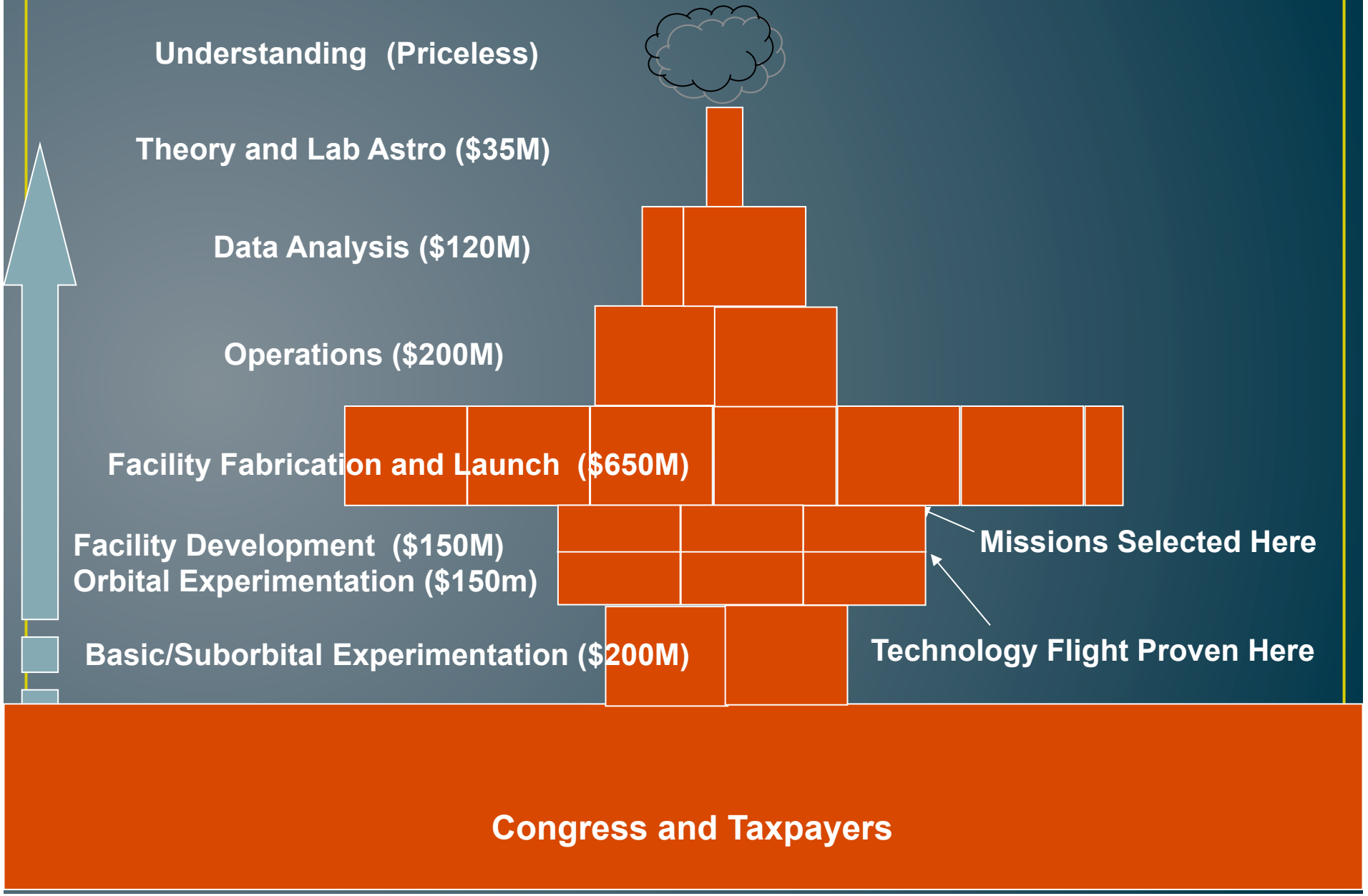
FY08 Astrophysics Edifice



More $$ Won't Solve the Problem

WE MUST SPEND IT DIFFERENTLY

A Better Balance



Recommendations for Debate and Possible Resolutions

- Better Balanced Spending
- Emphasize Flight Experience
  - Stress demonstration
  - Actual astronomy
- Make Mission Decisions at higher TRL
  - (create FRL? Flight Readiness Level)
- Build key components in advance
- Set Timetable and Goal Posts in advance
- Fix Peer Review –
  - has become deeply dysfunctional – killing us
  - make it accurate, consistent, responsive, transparent

How do we prepare for ASTRO2020?

Must have exozodis imaged and Jupiter spectra by end of 2019

Must fly "Explorer" by early 2018

Must start "Explorer" by early 2014

How Do We Prepare to Start "Explorer"?

We have only three years!

Need confidence that the Explorer will provide the needed astronomy
otherwise Explorer won't be allowed to proceed

Therefore:
We must demonstrate capability suborbitally in next three years
Must do actual astronomy suborbitally
Doesn't have to ground-breaking

Suborbital Demonstrations

Suborbital Demonstrations Can and Should be Done in 3 years.

If we can't do a suborbital demo in 3 years then we can't fly an Explorer in 4 years and there will be no confidence we can fly a flagship in eight years.

Lab development of scaled-up versions still needs to be done in parallel

Possible Exopag Recommendation

Exopag asks NASA for money for three suborbital demonstrations
- One for each of technologies mentioned in ASTRO2010
- Nulling Interferometers, Internal Coronagraphs and Starshades
- Fixed time and cost (tbd)

Set the goals clearly now
- What astronomy must be done to demonstrate practicality at each level? Suborbital, Explorer

Show clearly how the technology is extendable to the future.
- What will it take to do the Earth problem?
- How can the technology meet those goals

Exopag should play central role in peer review. We cannot allow a group of anonymous people with unknown credentials to make these decisions!

Remember…

If we don't do something different, we fail.

So

Whatever it is this group decides to do should not be negotiable.
Otherwise we are setting ourselves and NASA up for failure.

Lack of money from NASA is not an acceptable answer. We still fail.
Go back to decadal review with solid plan if necessary
Go to congress if necessary
But don't roll over!